NHTSA Tire Aging Project

Tire Exchange Program

3/19/2003

From October 2002 until March 2004 NHTSA's Applied Research Division will complete a project on tire aging. The main components include examining how tires are aging in the Southwestern U.S. as well as an evaluation of accelerated, laboratory-based tire aging methods. The goals of the research are to determine the most effective tire aging method and to develop an aged tire endurance test. In addition, it is hoped that this project will create a publicly accessible body of research on the tire-aging process.

The first phase of the project will consist of collecting tires of up to five years in age from service the Southwestern U.S. During the February to April 2003 time frame, NHTSA will be collecting over 700 tires from the Phoenix Arizona area under a system named the "NHTSA Tire Exchange Program". The Exchange Program utilizes local Phoenix automotive dealerships and tire retailers to purchase new tires for customers in exchange for the tires on the collection list. The collection group will consist of twelve different tires of various brands and sizes that are known to be performing well in that region. Half will be original equipment tires, half will be replacement tires. The original equipment tire models were selected using the following criteria:

- The tire was in production from 1998-2003
- The tire went through no "major" design changes during the 1998-2003 time frame
- The tire was original equipment on a least one vehicle during the vehicle's 1999-2003[1] model years
- The above vehicle was sold in the Phoenix Arizona area during its 1999-2003 model years

[1] Vehicle model years are listed as one ahead of the year the vehicle and tire were manufactured.

The replacement tires were selected using the following criteria:

- The tire was in production from 1998-2003
- The tire underwent no "major" design changes 1998-2003
- The tire was available in the Phoenix, Arizona market from1998-2003

The respective tire manufacturers confirmed that the OE tire models chosen for Phoenix area collection meet the aforementioned OE tire selection criteria (Table 1).

Table 1: Original Equipment Tire Collection List

Type	Use	Size	Load Index	Speed Rating	Brand	Model	OE Brand	OE Vehicle
P-metric	Compact car	P185/65R14	85	H	Hankook	H406	Daewoo Hyundai Kia	Nubira Accent Sephia II
P-metric	Mid-size car	P195/65R15	89	S	BFGoodrich	Touring T/A	Chevy	Cavalier
P-metric	Mid-size car	P205/65R15	92	V	Goodyear	Eagle GA	Lexus	ES300
P-metric	Mid-size SUV	P235/75R15	108	S	Michelin	LTX M/S	Ford Dodge	E 150 Van Ram Van 1500
P-metric	Large SUV	P265/75R16	114	S	Firestone	Wilderness AT	Chevy GMC	Silverado/Tahoe Sierra/Yukon
Metric	SUV	255/55R18	109	H	Goodyear	Wrangler HP	Land Rover	Range Rover 4.6 HSE / Discovery

Again, the respective tire manufacturers confirmed that the replacement tire models chosen for Phoenix area collection meet the aforementioned replacement tire selection criteria (Table 2).

Table 2: Replacement Tire Collection List

Type	Use	Size	Load Index	Speed Rating	Brand	Model	Retailer
P-metric	Mid-size car	P205/60R15	90	H	Kumho	ECSTA HP4[2]	Discount Tire
P-metric	Mid-size car	P205/65R15	92	S	Continental	Touring Contact A/S	Discount Tire
P-metric	Full-size car	P205/70R15	95	S	Yokohama	Avid Touring	Discount Tire
Metric	SUV	255/65R16	109	H	General	Grabber ST A/S[3]	Discount Tire
P-metric	Full-size car	P235/45R17	94	V	Pirelli	P6 FourSeason[4]	Discount Tire
LT	Full-size LT	LT245/75R16/E	120	Q	Pathfinder[5]	ATR A/S OWL	Discount Tire

Determination of the sizes of tires collected from the Phoenix area were based in part on the 2001 tire size popularities documented in Table 3. Notice that the top ten passenger car tire sizes only constitute about 40% of the passenger tires sold in 2001, indicating a large diversity in tire sizes.

Table 3: Tire Size Selections Based on 2001 Tire Size Popularity*

	OE Passenger Tires			Replacement Passenger Tires			Replacement LT Tires		
Rank	**Size**	**Percent**	**NHTSA**	**Size**	**Percent**	**NHTSA**	**Size**	**Percent**	**NHTSA**
1	P235/75R15	7.1	*	P235/75R15	8.9		LT235/85R16	16.8	
2	P205/65R15	5	*	P205/70R15	4.3	*	LT245/75R16	11.6	*
3	P255/70R16	4.7		P195/75R14	4.2		LT235/75R15	10	
4	P195/65R15	4.2	*	P205/65R15	4	*	31X10.50R15	9.5	
5	P225/60R16	4.1		P185/75R14	3.6		LT265/75R16	8.9	
6	P245/75R16	4		P205/75R14	3.5		LT225/75R16	7.7	
7	P185/65R14	3.9	*	P215/70R15	3.4		LT215/85R16	5.8	
8	P195/70R14	3.9		P205/75R15	3		30X9.50R15	3.9	
9	P215/60R15	3.4		P215/75R15	3		LT285/75R16	2.1	
10	P235/70R15	2.8		P195/70R14	2.8		33X12.50R15	1.8	
	Total	43.10%		**Total**	40.70%		**Total**	78.10%	
	Other Sizes	56.90%		**Other Sizes**	59.30%		**Other Sizes**	21.90%	

*Source: *TireBusiness.com – Market Data Book, Crain Communications Inc. All rights reserved.*
Duplicate size in both OE and replacement tires

[2] OE on the Daewoo Leganza CDX, SE, SX

[3] OE on the Mercedes ML320

[4] OE on the Audi A4 1.8T, 3.0 - A6 2.7T, 3.0 / Volvo V70, S60

[5] Kelly-Springfield is the manufacturer of the Pathfinder tire.

Tire brands were selected based on North American and global tire brand popularity, as documented in Table 4 and Table 5. Two tire models were selected from the larger tire manufacturers and one from the smaller manufacturers.

Table 4: Tire Brand Selections Based on Top 10 2001 North American Tire Sales*

Rank	Company	North American Tire Sales (in millions of dollars)	NHTSA
1	Goodyear Tire & Rubber Co (Kelly-Springfield)	$ 7,250	3
2	Michelin North America Inc (BF Goodrich)	$ 5,500	2
3	Bridgestone-Firestone Inc	$ 4,800	1
4	Cooper Tire & Rubber Co	$ 1,550	
5	Continental Tire North America Inc (General)	$ 1,550	2
6	Yokohama Tire Corp	$ 500	1
7	Toyo Tire (USA) Corp	$ 375	
8	Kumho Tire USA	$ 285	1
9	Hankook Tire America Corp	$ 215	1
10	Pirelli North American Tire	$ 170	1

*Source: *TireBusiness.com* – *Market Data Book, Crain Communications Inc. All rights reserved.*

Table 5: Tire Brand Selections Based on 2001 Global Tire Sales*

Rank	Company	Country	Global Tire Sales (in million of dollars)	NHTSA
1	Groupe Michelin (BF Goodrich)	France	13,425	2
2	Bridgestone Firestone Corp	Japan	12,950	1
3	Goodyear Tire & Rubber Co (Kelly-Springfield)	USA	12,470	3
4	Continental A.G.	Germany	4,900	2
5	Sumitomo Rubber Industries Ltd.	Japan	2,598	
6	Pirelli S.p.A.	Italy	2,530	1
7	Yokohama Rubber Co. Ltd.	Japan	2,272	1
8	Cooper Tire & Rubber Co.	USA	1,705	
9	Toyo Tire & Rubber Co. Ltd.	Japan	1,248	
10	Kumho Industrial Co. Ltd.	South Korea	1,247	1
11	Hankook Tire Co. Ltd	South Korea	1,119	1

*Source: *TireBusiness.com* – *Market Data Book, Crain Communications Inc. All rights reserved.*

Limitations in funding, resources, and the availability tire brands at participating Phoenix retailers limited the study to 12 tires from 8 different manufacturers.

Table 6 documents the analytical test that are planned to be carried out on tires collected from the Phoenix area:

Table 6: Planned Analytical Tire Tests

Test	Skim Rubber	Belt Edge Rubber	Tread	Sidewalls	Bead Area
Peel strength (perpendicular - twice)	*	*			
Total crosslink density	*	*	*	*	*
Crosslink density distribution*	*	*	*	*	*
Fixed oxygen by weight	*	*	*		
Tensile test					
Strain ratio	*	*			
Elongation at break (ultimate)	*	*			
100% modulus (room temp)	*	*			
100% modulus (70°C)	*	*			
Extension ratio at break	*	*			
Tensile strength	*	*			
Shore hardness	*	*	*		
Indentation modulus		?			
Air permeability (ASTM F1112-00)	New tires				
Analysis of inner-liner compound	New tires				
Microscopy					
Inner-liner thickness	New tires				
Wedge rubber thickness	New tires				
Skim rubber thickness	New tires				
Shearography	All tires				
Visual inspection / photos	All tires				
Initial skid depth	From manufacturer				
Tire spring rate	From manufacturer				

*Distribution of mono, di, & poly-sulfidic linkages - time and budget permitting.

In addition, a portion of the tires collected from the field, as well as new tires, will be run through the new FMVSS 139 Endurance Test to benchmark their performance.

Final Comments

All proposed tire models and tests mentioned in this document are tentative and are subject to change. Details of the NHTSA Tire Aging Project will be published on the following website and will be frequently updated: http://www-nrd.nhtsa.dot.gov/vrtc/vrtcstar.htm